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MAYAGUEZ, PUERTO RICO

BULLETIN NO. 41

A STUDY OF THE ADULT POPULATIONS OF THE WEST INDIAN FRUITFLY IN CITRUS PLANTINGS IN PUERTO RICO

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A STUDY OF THE ADULT POPULATIONS OF THE WEST INDIAN FRUITFLY IN CITRUS PLANTINGS IN PUERTO RICO

By L. C. McAlister, Jr., *entomologist, Division of Fruitfly Investigations,* W. A. McCubbin, *senior pathologist,* and G. A. Pfaffman, W. T. Owrey, H. G. Taylor, and I. W. Berryhill, *assistant plant quarantine inspectors, Division of Foreign Plant Quarantines, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.*[1]

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INTRODUCTION

The occurrence of fruitflies of the genus *Anastrepha* in Puerto Rico has long been known (*2*).[2] These fruitflies were for many years identified by various specialists (*3*) as *Anastrepha fraterculus* (Wied.); as late as 1924 Wolcott (*9, p. 229*), in his check list of the insects of Puerto Rico, recorded *A. fraterculus* as the only species, with *A. acidusa* (Walker) given as a synonym. In 1934 Greene (*1*) recognized two species of fruitflies, *A. suspensa* Loew and *A. acidusa*, from specimens collected in Puerto Rico, other islands of the West Indies, and Florida. In the year previous Seín (*6*) had described *A. unipuncta* as a new species, which Greene (*1*) placed in synonymy with *A. suspensa*, and had reported *A. acidusa* as *A. fraterculus* variety *mombinpraeoptans*. Stone (*7*) considered the type of *A. acidusa* (Walker) to belong to a genus quite different from that of the West Indian fruitflies, and

[1] The writers are indebted to A. S. Mills for valuable assistance in connection with the establishment and operation of the traps in the north coast area during the period April to June 1937.

Grateful appreciation is expressed to the Puerto Rico Experiment Station, U. S. Department of Agriculture, for cooperation in furnishing headquarters space at Mayaguez, and to the Postmaster and the Lighthouse Service for cooperation in furnishing laboratory and storage space at San Juan.

[2] Italic numbers in parentheses refer to Literature Cited, p. 16.

raised *mombinpraeoptans* to specific rank, since it is readily distinguishable from *fraterculus*. Thus the West Indian fruitflies in Puerto Rico are now considered to comprise two species, *A. suspensa* and *A. mombinpraeoptans* Seín.

Common names for *Anastrepha suspensa* and *A. mombinpraeoptans* have not been designated, and in this paper the two species have been referred to collectively as West Indian fruitflies. In all references to fruitfly infestation in citrus fruits, however, the common name "West Indian fruitfly" has been used exclusively for *A. suspensa*.

Before the two species of *Anastrepha* occurring in Puerto Rico had been established taxonomically, however, it was recognized that the two forms could be conveniently differentiated on the basis of host selection. Tower (*8*), in 1911, published an account of the life history of the fruitfly reared from mango (*Mangifera indica* L.) under the name *A. acidusa* as determined by W. R. Walton. Seín (*6*) recorded notable differences in the host selections of the two species. One species, *A. mombinpraeoptans*, had strong preference for certain fruits of the family Anacardiaceae (mango and hog plum, *Spondias* spp.). The other species, *A. suspensa*, had as principal preferred hosts in Puerto Rico rose apple (*Caraphyllus jambos* (L.) Millsp.) and guava (*Psidium guajava* L.) and had sporadically attacked citrus fruits (grapefruit, orange, sour orange, and kumquat) under certain favorable conditions.

In Puerto Rico *Anastrepha mombinpraeoptans* has occasionally also attacked rose apple and guava, and has been recorded from cashew nut (*Anacardium occidentale* L.). *A. suspensa* has sporadically attacked West Indian almond (*Terminalia catappa* L.) and has been recorded from star-apple (*Chrysophyllum cainito* L.), sapodilla (*Achras sapota* L.), custard-apple (*Annona reticulata* L.), cocoa-plum (*Chrysobalanus icaco* L.), Malayapple (*Jambosa malaccensis* (L.) DC.), and Surinam-cherry (*Eugenia uniflora* L.).

The relationship of these fruitflies to citrus fruits in Puerto Rico has long been a perplexity. McAlister (*4*), working in Florida in 1933, had demonstrated that both *Anastrepha suspensa* and *A. mombinpraeoptans* (*A. acidusa*) would attack citrus fruits under cage conditions in the laboratory, and in the inspection work of the Bureau in Puerto Rico a small number of citrus fruits containing *Anastrepha* larvae had been disclosed each season since 1931. All the specimens reared from the infested citrus fruits encountered in these earlier grove inspections, however, were *A. suspensa*. It was thus manifested that *A. suspensa* was implicated as a possible pest of citrus fruits, but an adequate knowledge of the economic significance of this insect was lacking. The present study was designed, therefore, to determine in citrus plantings in Puerto Rico the relationship of adult populations of the West Indian fruitflies to subsequent larval infestations in the fruit and also to determine some of the causes of possible fluctuations in these populations.

METHODS AND PROCEDURE

The study of populations of adult fruitflies was conducted by means of series of glass traps maintained in 12 representative citrus plantings or groves. Series of traps were also maintained in guava, mango, and rose apple, principal preferred host fruits of the fruit-

flies in Puerto Rico, to determine the comparative populations of adults in these locations.

All the traps contained a lure which had been found to be highly attractive to the *Anastrepha* in Puerto Rico.

This lure was made as follows:

Material	*Quantity*
No. 1:	
Calcium caseinate	25 gm.
Sodium hydroxide	20 gm.
Water	to make 1 liter.
No. 2:	
Household ammonia	85 ml.
Imitation vanilla essence	25 ml.
Water	767 ml.
Finished lure:	
Solution No. 1	500 ml.
Solution No. 2	500 ml.
Honey	80 ml.

Later work by the senior author has shown that a decomposing casein lure, similar to that given under No. 1, may be more attractive under certain conditions, at least to *Anastrepha suspensa*, than the lure consisting of ammonia, vanilla, and decomposing casein plus honey which was used in the traps for this study. McPhail (*5*), who discovered the attractiveness to fruitflies of decomposing proteins, and who in that work first used a casein-sodium hydroxide formula, did his work in Mexico mainly with *A. striata* Schiner.

Six citrus plantings in the western mountainous area of Puerto Rico were selected as representative of the conditions in that area and traps were maintained therein from April 1937 to June 1938. Traps were also maintained during the same period in six representative grapefruit groves in the north coast area, the main citrus-producing section of the island. The traps in the western area were operated from Mayaguez and those in the north coast area from San Juan. Each series of traps was inspected at weekly intervals, the captured insects removed, identified, and counted, the old lure replaced with new solution, and the traps returned to their locations in the trees.

WESTERN MOUNTAINOUS AREA [3]

The western part of Puerto Rico in general is characterized by a mountainous terrain apparently not readily adaptable to the production of citrus fruit as the main crop. Most of the citrus plantings in the mountainous section of the island were grown as shade for coffee. The citrus plantings were mostly irregular, usually in the small valleys or on steep hillsides, and with little or no attention having been given to the production of citrus fruits as the primary crop. Usually an abundance of citrus fruits, however, principally oranges, has been produced in the mountainous area. Owing to the requirements of shade for coffee production and lack of intensive agricultural development in the mountainous area, a relative abundance of hosts other than citrus fruits occurred in or near these citrus

[3] The writers appreciate the courtesy of the following individuals who cooperated by allowing the operation of traps on their properties in the mountainous area: M. K. Fletcher, Eugenia Grove, Mayaguez; Alejandro Marini, Las Marias; Ramón Echandia, San Sebastian; Pedro Vincenty, Quinta Pomarrosas, Maricao; Ramón Quiñones, Dos Rios Farm, Maricao; and Paco del Moral, Maricao.

plantings. The earliest observations of sporadic attacks by the West Indian fruitfly on citrus fruits in Puerto Rico were made in the mountainous area.

NORTH COAST MAIN CITRUS BELT AREA [4]

Most of the commercial production of citrus fruit in Puerto Rico has been restricted to a belt along the north coast of the island, which extends from Arecibo on the west to Rio Piedras on the east. This area in general is characterized by more or less sandy soil, comparatively level terrain, and relative scarcity of hosts other than citrus fruits. The whole area was in general under intensive cultivation and was thickly populated. Owing to the usually prompt harvesting of fruit from the groves, infestation of the West Indian fruitfly in citrus fruits had been found on only 5 scattered properties prior to 1937, but, because of holding a large part of the fruit until late in the marketing season, 12 sporadic outbreaks of larval infestations occurred in the 1937 season and 22 in 1938. In both the 1937 and 1938 seasons, as well as in previous years, these sporadic outbreaks of larval infestations caused no commercial loss of fruit.

OCCURRENCE OF ADULT FRUITFLIES IN CITRUS PLANTINGS

In all the 12 groves or plantings included in this study it was noteworthy that adults of both species occurred in some numbers throughout most of the year; particularly in all groves but one in the main citrus belt along the north coast of the island did flies occur every month of the year.

The average number of adults of *Anastrepha suspensa* that were trapped during each month in each of the six citrus plantings in the mountainous area and in each of the six groves in the north coast area is shown in table 1.

TABLE 1.—*Anastrepha suspensa occurring in traps in citrus plantings in Puerto Rico from April 1937 to June 1938, by months*

Area and planting	Average number of flies captured per trap-week [1]											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mountainous area:												
Eugenia	0.02	0.36	0.08	0.10	0.03	0.20	0.32	0.11	0.05	0.03	0.05	0.02
Marini	0	.01	.01	.30	.36	2.09	.37	.05	.02	.01	0	0
Echandia	0	0	.01	.01	.01	.08	.15	.09	.01	.01	0	0
Vincenty	.09	.15	.01	.09	.18	1.01	.58	.63	.11	.11	.13	0
Quiñones	.01	.08	.14	.02	.05	1.06	.81	.31	.03	.12	.08	0
Moral	0	0	0	0	0	1.31	6.62	1.62	.06	.02	.05	0
Average [2]	.01	.14	.05	.09	.10	.90	.85	.25	.04	.05	.04	.01
North coast area:												
Hills Brothers	.01	.09	.08	.01	.01	.01	.24	.34	.04	.16	.35	.06
Vosburg	.01	.02	.05	.02	.03	.05	.23	.32	.10	.24	.60	.04
Roberts	.09	.04	.04	.01	.02	.01	.12	.38	.20	.54	.49	.13
Vassallo	.01	.08	.17	.05	.01	.01	.15	.18	.09	.20	.20	.06
Mitchell	0	.01	.01	.01	.01	0	.02	.03	.02	.04	.06	.01
Stevenson	.01	.11	.10	.02	.05	.04	.05	.09	.03	.04	.08	.01
Average [2]	.02	.06	.07	.02	.02	.02	.14	.22	.08	.21	.30	.05

[1] 1 trap operating for 1 week. Records for months that overlapped have been averaged.
[2] Average number of flies per trap-week for entire area.

[4] The following individuals kindly cooperated in this project by allowing the operation of traps on their properties in the north coast area: Hills Brothers, Rio Piedras; C. Vosburg, Rio Piedras; E. M. Vassallo, Guaynabo; E. B. Roberts, Bayamon; B. Stevenson, Palo Seco; and A. B. Mitchell, Bayamon.

Approximately two-thirds of the flies in the mountainous area occurred from the middle of June to the end of July. Except in the Eugenia grove, the citrus fruit had all been harvested before the end of May in both 1937 and 1938. Thus the occurrence of the bulk of the adults in the mountainous area was not associated with the presence of fruit.

Two specimens of *Anastrepha* new species "F," both females, were trapped in the mountainous area. The first specimen was captured on June 28 and the second on August 16, 1937. Baker [5] has emphasized the existence of various fruitfly faunal zones, one of which he believes to comprise the major part of the West Indies, the Florida Keys, and a fringe of the adjacent Florida coasts. If such be the case, it is not surprising to find the species common in Puerto Rico appearing on the Florida Keys, and the capture of new species "F" in Puerto Rico, the first known occurrence of it outside of Florida, is of special significance.

In the north coast area there was a more even distribution of flies over the year than was observed in the mountainous area. Approximately one-half the total number of adults of *A. suspensa* trapped occurred in the main citrus belt from the latter part of July to the middle of November. In both 1937 and 1938 fruit remained on the trees in many of the groves in the north coast area until the end of July, but the presence of adults of *A. suspensa* was not correlated with the presence of fruit; more flies were trapped after the old crop had been removed and before the new crop of grapefruit was mature than when ripe fruit was on the trees.

The occurrence of *Anastrepha mombinpraeoptans* in citrus plantings in the mountainous area, as shown in table 2, appeared to be associated closely with the principal fruiting season of mangoes in or near each planting. The adults of *A. mombinpraeoptans* occurred in slightly less numbers than did the adults of A. *suspensa* in this general area, but in one planting, the Vicenty grove, the number of A. *mombinpraeoptans* greatly exceeded that of *A. suspensa.* The bulk of *A. mombinpraeoptans* occurred in traps in the mountainous area from July to September shortly after the period when mangoes were fruiting in the area.

Anastrepha mombinpraeoptans occurred in the citrus groves in the north coast area (table 2) throughout the year. The occurrence of the bulk of flies in the traps during and shortly after the period when mangoes and hog plums were fruiting was apparent. In the north coast area the total number of *A. mombinpraeoptans* trapped in citrus groves was almost three time that of *A. suspensa.* As mangoes, a preferred host of *A. mombinpraeoptans*, grew in abundance adjacent to or near the groves in this area, and as preferred hosts of *A. suspensa* were not abundant, it was probably natural that the population of adults of *A. mombinpraeoptans* should exceed that of *A. suspensa* in these groves.

[5] BAKER, A. C. Personal communication.

TABLE 2.—*Anastrepha mombinpraeoptans occurring in traps in citrus plantings in Puerto Rico, from April 1937 to June 1938, by months*

Area and planting	Average number of flies captured per trap-week [1]											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mountainous area:												
Eugenia	0.01	0.10	0.02	0.16	0.16	0.35	0.37	0.47	0.04	0.01	0.02	0.01
Marini	.01	0	.01	.02	.07	.08	.04	.03	.01	0	0	0
Echandia	.01	0	0	0	0	.01	.04	.08	.01	0	0	.01
Vincenty	.01	.21	.04	.06	.04	.24	.26	5.04	3.70	.60	.08	0
Quiñones	0	.03	.05	0	.01	.21	.32	2.31	.45	.07	.01	0
Moral	0	0	0	0	.01	.17	1.84	4.82	1.29	.10	0	0
Average [2]	.01	.05	.01	.05	.04	.17	.32	1.05	.53	.09	.01	.01
North coast area:												
Hills Brothers	.01	.02	0	.01	.01	.12	1.02	.53	.20	.77	.35	.03
Vosburg	.01	0	.01	.08	.25	1.02	2.10	.51	.43	.83	.55	.03
Roberts	.02	.01	.01	.01	.04	.11	.52	.67	1.20	.51	.18	.05
Vassallo	0	.01	.03	.02	.05	.13	.06	.10	.07	.25	.07	0
Mitchell	0	0	0	0	.02	.07	.16	.62	.18	.42	.09	.01
Stevenson	0	.01	.02	.13	.65	1.97	.32	.20	.15	.18	.02	0
Average [2]	.01	.01	.01	.04	.34	.56	.70	.44	.37	.48	.22	.02

[1] 1 trap operating for 1 week. Records for months that overlapped have been averaged.
[2] Average number of flies per trap-week for entire area.

OCCURRENCE OF ADULTS IN PREFERRED HOSTS

As has been noted previously, the two species of *Anastrepha* appeared to have strong host preferences or selections in Puerto Rico. The early investigators of the fruitfly-citrus fruit relationship in the island considered that larval infestations in citrus fruits were accidental or at least incidental to the presence of large adult populations in nearby or adjacent trees of preferred hosts. Seín (*6*) considered that "the elimination of these (preferred) host plants would eliminate the source of flies in the vicinity of the groves and therefore also the danger of infestation."

Some of the infestations that occurred in 1937 and 1938 in the main citrus belt, however, could not be accounted for on the basis of nearby or adjacent preferred fruitfly hosts. Occasional infestation in grapefruit was found in localized sites that were about a mile from any known preferred host plants. The preferred host trees, of course, furnished the original flies that migrated to the groves, but the main point was that the flies traveled considerable distances to reach the localized sites where larval infestations occurred. The elimination of the preferred fruitfly hosts adjacent to or in the immediate vicinity of the groves apparently would not have eliminated all the flies in the groves and therefore not all the danger of infestation.

There was, nevertheless, an apparent correlation of the number of adults that occurred in citrus plantings with the number of each species that occurred in their respective principal preferred hosts. The number of *Anastrepha* captured in traps in three principal preferred hosts at Mayaguez is shown in table 3.

TABLE 3.—*Number of Anastrepha adults captured in traps in three principal hosts, Mayaguez, P. R., from April 1937 to June 1938, by months*

Month	Guava			Mango			Rose apple		
	Trap [1] weeks	*A. suspensa*	*A. mombinpraeoptans*	Trap [1] weeks	*A. suspensa*	*A. mombinpraeoptans*	Trap [1] weeks	*A. suspensa*	*A. mombinpraeoptans*
January	180	158	4	72	14	38	60	9	0
February	180	270	10	72	44	332	120	38	3
March	225	170	23	90	4	1,893	75	51	5
April	126	81	4	72	4	1,702	60	95	1
May	72	78	13	72	2	2,411	75	295	10
June	72	227	106	72	113	6,658	60	144	9
July	36	843	55	72	203	3,411	75	959	6
August	90	3,272	56	30	26	272	60	53	0
September	90	4,506	38	24	34	76	60	12	1
October	90	2,638	6	24	75	4	45	9	0
November	90	425	0	30	41	1	60	6	0
December	90	57	0	30	18	6	60	4	0
Total		12,725	315		578	16,804		1,675	35

[1] 1 trap operating for 1 week.

It will be noted that the bulk of *Anastrepha suspensa* occurred in guava bushes from August to October, when the main summer crop of guava fruits was being produced. The relatively large population of flies that occurred in the groves in the north coast area during October and November (fig. 1) very probably was a small part of the adults that were produced earlier in the year in guava fruits.

In the mountainous area a large population of *Anastrepha suspensa* came from the rose apple. The rose apple produced fruit in this area from the middle of May to the first week in July. The adults of *A. suspensa* from rose apple apparently reached the peak of abundance in June and July. The large population of *A. suspensa* in the citrus plantings in the mountainous area during June and July (fig. 1) was seemingly associated with the general movement of adults from rose apple. This large population of *A. suspensa* adults occurred in the citrus plantings in the mountainous area 2 months after the current crop had been removed. While the rose apple occurs only in relatively small numbers in the north coast area, about one-fourth of the population of *A. suspensa* in these citrus groves was apparently associated with the movement of flies from this excellent host.

The period of occurrence of *Anastrepha mombinpraeoptans* in citrus plantings in the mountainous area and also in the groves of the main citrus belt (fig. 1) was obviously associated with the period of its development in mango and in hog plum. Adults of *A. mombinpraeoptans* occurred in citrus plantings in close association with adults of *A. suspensa*, and their migratory habits appeared to be similar in that both had a tendency at certain seasons to seek new fields for reproduction, protection, and food.

RELATIVE POPULATIONS OF ADULTS IN CITRUS PLANTINGS AND IN PREFERRED HOSTS

The apparently close association of the occurrence of adults in citrus plantings with the development of each species in its respective prin-

cipal preferred hosts naturally leads to the question of the relative sizes of the populations of adults that occurred in the two environments. The populations of each species that occurred in citrus plant-

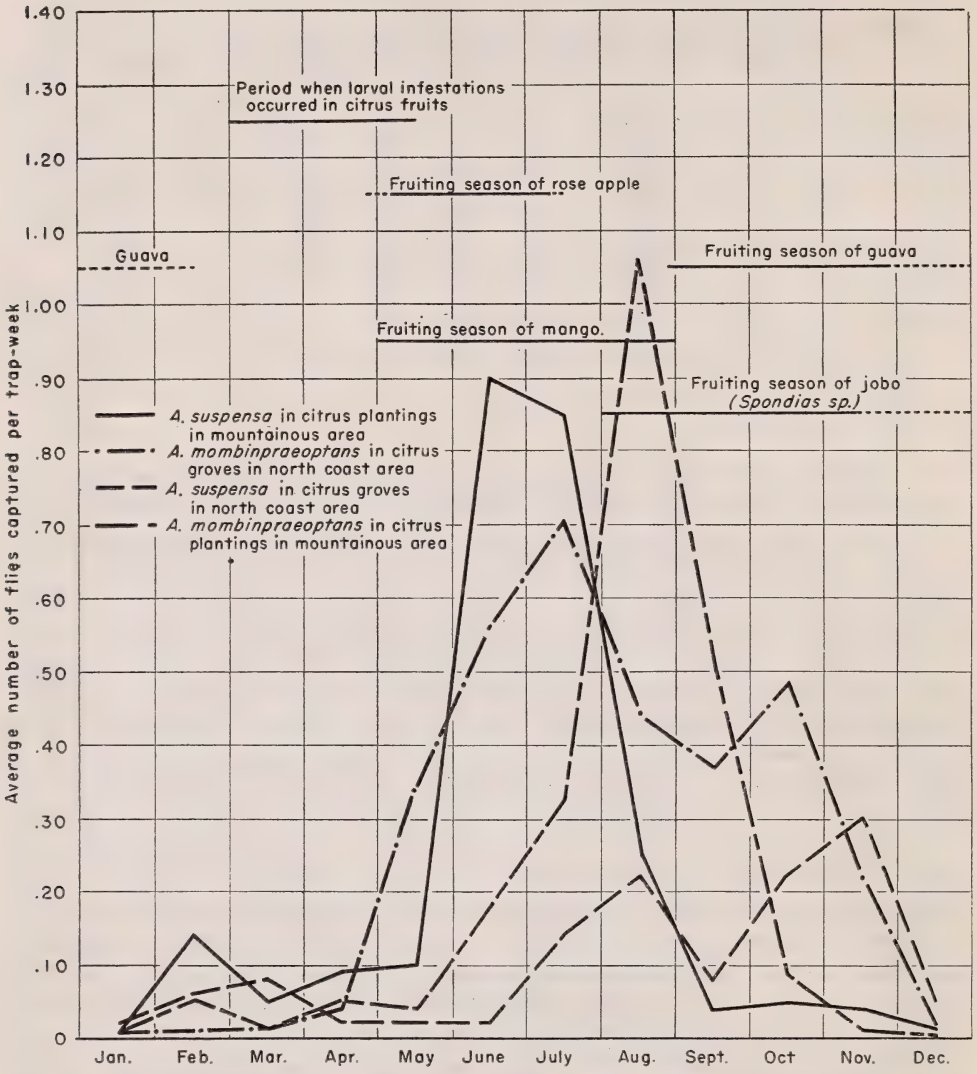

FIGURE 1.—Occurrence of adults of *Anastrepha suspensa* and *A. mombinpraeoptans* in citrus plantings in relation to the fruiting seasons of their principal preferred hosts in Puerto Rico from April 1937 to June 1938, by months.

ings in the mountainous area and also in the main citrus belt have been compared in table 4 on the basis of the average number of flies captured per trap-week (one trap operating for 1 week) with the corresponding populations of each species that occurred in mango trees, guava bushes, and rose apple trees.

TABLE 4.—*A comparison of the number of fruitflies trapped in citrus plantings with the number occurring in three principal preferred hosts, from April 1937 to June 1938, by months.*

Month	Average number of *Anastrepha* captured per trap-week [1] in—									
	Citrus plantings in the mountainous area		Citrus plantings in the north coast area		Mango trees in the mountainous area		Guava bushes in the mountainous area		Rose apple trees in the mountainous area	
	A. suspensa	*A. mombinpraeoptans*	*A. suspensa*	*A. mombinpraeoptans*	*A. suspensa*	*A. mombinpraeoptans*	*A. suspensa*	*A. mombinpraeoptans*	*A. suspensa*	*A. mombinpraeoptans*
January	0.01	0.01	0.02	0.01	0.19	0.53	0.88	0.02	0.15	0.00
February	.14	.05	.06	.01	.61	4.61	1.50	.06	.32	.03
March	.05	.01	.07	.01	.04	21.03	.76	.10	.68	.07
April	.09	.05	.02	.04	.06	23.64	.64	.03	1.58	.02
May	.10	.04	.02	.34	.03	33.49	1.08	.18	3.93	.13
June	.90	.17	.02	.56	1.57	92.47	3.15	1.47	2.40	.15
July	.85	.32	.14	.70	2.82	47.38	23.42	1.53	12.79	.08
August	.25	1.05	.22	.44	.87	9.07	36.36	.62	.88	0
September	.04	.53	.08	.37	1.42	3.17	50.07	.42	.20	.02
October	.05	.09	.21	.48	3.13	.17	29.31	.07	.20	0
November	.04	.01	.30	.22	1.37	.03	4.72	0	.10	0
December	.01	.01	.05	.02	.60	.20	.63	0	.07	0

[1] 1 trap operating for 1 week.

The comparatively small populations of adults that occurred in traps in citrus plantings was striking. At no period did the populations of either *Anastrepha suspensa* or *A. mombinpraeoptans* in citrus plantings exceed the numbers of each species that occurred in their respective preferred hosts. The population of adults of both species in citrus plantings was infinitesimal during most of the year and could hardly be compared on the same basis with the numbers of flies that were trapped among the preferred hosts.

Guavas in practically all locations were essentially 100-percent infested, and often each fruit contained from one to eight or more larvae. The species that reproduced in guavas was mainly *Anastrepha suspensa*, with a small proportion of *A. mombinpraeoptans*. The same was true of the rose apple, which was abundant in the mountainous area. Most of the varieties of mangoes were heavily attacked by *A. mombinpraeoptans*, but in Puerto Rico *A. suspensa* has not been known to breed in mango. Such favorable hosts being usually abundant in their normal fruiting seasons, it seemed only natural that large populations of adults should have been produced in these environments. The nonoccurrence of large populations of flies in citrus plantings at any time indicated that the citrus fruits could not have been heavily infested. The adults present throughout the season in the citrus plantings appeared to be largely, if not entirely, those that had migrated from other hosts, since no evidence was obtained to indicate that the populations of flies had increased by development in citrus fruits.

Although *Anastrepha suspensa* has not been known to breed in mango fruits in Puerto Rico, the population of adults of this species trapped in mango trees exceeded the number occurring in citrus plantings throughout the year, except during March, April, May,

and June. The population of *A. suspensa* adults in mango trees was less than that in the citrus groves in the north coast area during 2 months only, March and May, when the populations were so close that the difference could hardly have been significant. The population of *A. suspensa* adults that occurred in citrus plantings in the mountainous area exceeded that in mango during 3 months, but the differences here also were small. Apparently the species *A. suspensa* had a peculiar habit of migrating over large areas into various trees, including mango and citrus. In general the adults appeared to occur in mango trees to a greater extent than in citrus plantings. The peculiar habit of the adults of *A. suspensa* of frequenting mango trees in noticeable numbers, particularly from June to November, was first observed in 1936 by the senior author and J. W. Balock, and this habit has been observed every year since that time. Careful efforts to rear *A. suspensa* from mango fruits, however, have given negative results.

RELATION OF PREFERRED HOST TREES TO THE OCCURRENCE OF FRUITFLIES IN CITRUS PLANTINGS

Grapefruit at the Marini grove near Las Marias has had larval infestations to some extent every season since 1931, and in 1937 perhaps the heaviest larval infestation ever observed anywhere on the island occurred in one small section of this grove. The previous history of infestations at this grove showed that they always occurred in exactly the same location. Two sides were bordered by considerable numbers of rose apple trees, and the grove appeared to be a most favorable site for the occurrence of fruitflies. Trap records showed that a large population of *Anastrepha suspensa* flies did occur in the grapefruit trees at the Marini grove, particularly during the fruiting season of rose apple. The traps in this grove were arranged in three groups with respect to distance from the rose apple trees. One group of 19 traps was set in grapefruit trees adjacent to the rose apple trees, a second group of 17 traps in trees approximately 100 feet from the rose apples, and a third group of 14 traps in trees approximately 300 feet from the rose apple trees.

During the year the first group of 19 traps captured 336 *Anastrepha suspensa* and 38 *A. mombinpraeoptans*, the second group of 17 traps captured 489 *A. suspensa* and 35 *A. mombinpraeoptans*, and the 14 traps located about 300 feet away from the rose apple trees captured 492 *A. suspensa* and 31 *A. mombinpraeoptans*. Thus the traps located the greatest distance from the preferred host trees captured the largest number of *A. suspensa* and almost equal numbers of *A. mombinpraeoptans*.

Apparently none of the traps was located at sufficient distances from the rose apple trees to get any considerable differences in the number of flies trapped, or perhaps the entire grove may be considered to be a favorable collecting basin for flies. The adults were apparently more or less evenly distributed over the area. The larval infestations every season, however, have been peculiarly restricted to the same small section of the grove, perhaps involving an area of not more than 2 acres.

The other citrus plantings in the mountainous area included in this study had no such marked concentration of closely adjacent preferred hosts as occurred at the Marini grove, and no attempt was made to study the distribution of flies with respect to distances from the preferred host plants. The flies captured in the other plantings appeared to be rather evenly distributed over the sections in which traps were placed. Throughout the period of this study there appeared to be no marked concentration of flies in any particular trees or localized sites in any of the plantings in the mountainous area.

In 2 of the grapefruit groves in the north coast area mango trees had been planted to serve as windbreaks. In each of these 2 groves 25 traps were placed in grapefruit trees adjacent to the mango trees and 25 traps were located near the center of the grove. The occurrence of flies in the traps located with respect to distance from the mango trees is shown in table 5.

TABLE 5.—*Number of Anastrepha adults captured in traps adjacent to mango trees and in traps at the center of two groves in the north coast area, from April 1937 to June 1938*

Grove	Flies captured in traps adjacent to mango trees		Flies captured in traps in center of grove	
	A. suspensa	*A. mombinpraeoptans*	*A. suspensa*	*A. mombinpraeoptans*
Stevenson	48	842	50	212
Vosburg	253	1,160	144	441
Total	301	2,002	194	653

Apparently the proximity of mango trees had considerable influence on the occurrence of *Anastrepha mombinpraeoptans* in the two grapefruit groves, as the traps in grapefruit trees adjacent to the mango trees captured almost three times as many flies of this species as those in the center of the grove. The proximity of mango trees also probably influenced the occurrence and distribution of adults of *A. suspensa* in the groves, as the traps in grapefruit trees adjacent to mango trees captured slightly more than twice as many flies as did those located in the center of the grove. Moreover, at the Vosburg grove the catch of flies in the 25 traps adjacent to mango trees showed definitely descending numbers of both species away from the mango trees in the three rows in which the traps were arranged. It has already been explained that at certain seasons of the year adults of *A. suspensa* occur in mango trees in larger numbers than those of *A. mombinpraeoptans*, and it was probably natural that some of these should have been captured in grapefruit trees adjacent to mango trees.

Two other groves in the north coast area had guava bushes and rose apple trees growing in wooded ravines nearby. In each of these groves 25 traps were placed in grapefruit trees near the ravines and 25 traps were placed in trees in the center of the groves. The occurrence of flies in the traps located with respect to distance from the wooded ravines is shown in table 6.

TABLE 6.—*Number of Anastrepha adults captured in traps near wooded ravines and in traps in center of the groves, north coast area, from April 1937 to June 1938*

Grove	Flies captured in traps near wooded ravine		Flies captured in traps in center of grove	
	A. suspensa	*A. mombinpraeoptans*	*A. suspensa*	*A. mombinpraeoptans*
Roberts	350	446	117	301
Mitchell	36	299	11	48
Total	386	745	128	349

It will be seen readily that a considerably larger number of flies of both species were captured in the traps located near the preferred hosts in the ravines than were captured in the center of the groves.

The distribution in the groves of flies of both species was apparently affected considerably by the presence of mango and other trees in the immediate vicinity. Such nearby host plants, however, could not be considered the source of all flies that were trapped in the groves. It seems probable that flies migrated to these situations to seek shelter and protection.

NUMBER OF LARVAE PER FRUIT

Both species of *Anastrepha* in Puerto Rico generally reproduced bountifully in their preferred host fruits. Few fruits were without infestation and practically all contained many larvae. In contrast, an infinitesimal proportion of the citrus fruit was attacked, usually with a low average number of immature stages per fruit.

During the 1938 season the larvae were reared from 202 infested grapefruit from the north coast area, and from these fruits 161 puparia were obtained. The average number of puparia was thus about 0.8 per fruit. The highest infestations of fruit recorded in this series were: 4 grapefruit, 8 puparia; 4 grapefruit, 7 puparia; and 4 grapefruit, 7 puparia. From the 161 puparia 111 adults were reared, of which 109 were *Anastrepha suspensa* and 2 were *A. mombinpraeoptans*. From 144 infested fruits collected at the Marini grove during the 1937 season 167 puparia were obtained, from which 112 adults, all *A. suspensa*, were reared. From another collection of 87 infested grapefruit from the Marini grove during the 1937 season 106 puparia were obtained, and from the puparia 53 flies, all *A. suspensa*, were reared. Thus it may be seen that in citrus in Puerto Rico the general average number of immature stages per fruit has been low.

ANASTREPHA MOMBINPRAEOPTANS IN CITRUS FRUITS

The trap records have indicated that nearly three times as many adults of *Anastrepha mombinpraeoptans* as of *A. suspensa* were captured in the groves in the north coast area, and that in the citrus plantings in the mountainous area the number of *A. mombinpraeoptans* was only slightly less than that of *A. suspensa*. The species *A. mombinpraeoptans*, however, has not been found breeding to any perceptible extent in citrus fruits in Puerto Rico. From 1,528 adult specimens

reared from infested citrus fruits during the period 1932 to 1938, 5 specimens only, including the 2 flies referred to above, have been identified as *A. mombinpraeoptans*. All these 5 specimens of *A. mombinpraeoptans* were reared from grapefruit collected adjacent to mango trees in the north coast area.

Thus there appears to be little doubt that *Anastrepha mombinpraeoptans* has not been a citrus-breeding fruitfly under normal conditions in Puerto Rico. The occurrence of adults of *A. mombinpraeoptans* in close association with *A. suspensa* in the citrus plantings, however, indicated a general parallelism in their migratory habits. Apparently this species was capable to an even lesser extent than *A. suspensa* of increasing its population of adults by development in citrus fruits.

LARVAL INFESTATIONS IN CITRUS PROPERTIES

The larval infestations that occurred in citrus fruits in the mountainous area seemed to have been associated with a small influx of flies, *Anastrepha suspensa*, during the latter part of February, and similarly the larval infestations that occurred in the main citrus area appeared to have been associated with a movement of a small number of this species into the citrus groves about the first of March. Larval infestations were found at least 2 months before the bulk of *A. suspensa* was trapped in the mountainous area and at least 4 months before the bulk of *A. suspensa* was trapped in the main citrus area. Thus the occurrence of the bulk of the adults of both species in either area (fig. 1) was not associated with their development in citrus fruits or with attraction by the ripe fruit. The larval infestations that were disclosed in the groves included in this study occurred sporadically from March to May, and all these slight larval infestations were of short duration. These initial attacks on the fruit disappeared soon after the adult population had decreased and at the time when citrus fruits presumably were in prime condition for infestation.

With the presence of a small but definite population of flies in citrus plantings late in February or early in March, at a presumably opportune time for fruitfly infestation, it would have been expected that subsequent serious infestation of the citrus fruit should have developed. Yet the development of serious larval infestations in citrus fruits, from the commercial viewpoint, has not occurred in Puerto Rico, presumably the native home of these two species of *Anastrepha*.

The record of the number of properties having larval infestation in citrus fruits was not therefore an accurate measure of the commercial or economic importance of the West Indian fruitfly to the citrus industry in Puerto Rico, for the reason that the number of fruits infested in each case was usually infinitesimal. The occurrence of larval infestations in citrus fruits on 22 properties in the north coast area during the 1938 season, probably a normal fluctuation due to the holding of a large part of the fruit until late in the marketing season, gave an opportunity not heretofore available to obtain some information on the economic importance of the West Indian fruitfly in this area. Sufficient fruit was examined during the 1938 season to give a fair basis for an estimate on this point. It would be incorrect, however, to use the direct number of fruits examined (17,814) in the groves showing sporadic infestations and the number found infested (231) as

representing the injury in these 22 groves, although the proportion of infested fruits (1.3 percent) derived from these figures would hardly represent a sufficient quantity of fruit to be of any really significant commercial importance. The actual damage to fruits on the trees was far below that obtained by the expert selection of drops and other fruits used for this inspection and as a basis for the above figures.

In an attempt to estimate the economic importance of the West Indian fruitfly to the citrus fruit industry in Puerto Rico, the basic numbers of fruit examined and fruit infested should be modified to take into account the expert selection of fruits for the examination. The extent of infestation by the West Indian fruitfly in 1938 has been estimated by the authors to be not more than 1 fruit in 5,000 fruits (i. e., 1 fruit in about 52 boxes) in the 4 groves which had the greatest amount of infestation and 1 in 37,500 (i. e., 1 fruit in about 390 boxes) in the 18 groves which had light infestation. This estimate is only approximate and involves a large element of judgment; but if the above estimate were doubled or quadrupled the damage to citrus fruits, even in the groves with the highest infestation, would still have been far below any point of commercial significance.

This estimate was based on the records obtained during the season in which larval infestations occurred in citrus fruits on the largest number of properties heretofore recorded. The estimate did not include, however, the large number of citrus properties in both the main citrus belt and in the mountainous area on which larval infestations have never been found, although such uninfested properties presumably were exposed to the same danger of infestation.

SUMMARY

A study of the population of adults of *Anastrepha suspensa* and *A. mombinpraeoptans* that occurred in representative citrus groves or plantings in Puerto Rico was conducted during the period April 1937 to June 1938 by means of series of glass traps maintained in six groves each in the mountainous area and in the main citrus belt. Adults of both species were present in the citrus plantings generally, particularly in the main citrus belt, throughout the year.

In the citrus plantings in the mountainous area as well as in the groves in the main citrus belt, there were considerable seasonal fluctuations in the populations of adults of the two species. The occurrence of the bulk of the adults of both species in the citrus plantings in the two areas apparently was not associated with their development in citrus fruits or with attraction of the fruit.

Two specimens of *Anastrepha* new species "F" were trapped in the mountainous area during the summer of 1937, and this record represents the first known occurrence of this species outside the State of Florida.

Approximately two-thirds of the adults of *Anastrepha suspensa* captured in citrus plantings in the mountainous area occurred from the middle of June to the end of July, this period corresponding with the fruiting season of the rose apple. Slightly over one-half the adults of *A. suspensa* that occurred in the groves in the main citrus belt were trapped from the latter part of July to the middle of November, this period corresponding with the combined fruiting seasons of rose apple

and guava. The occurrence of these relatively large populations of adults in the two areas during these periods was not associated with the presence or attraction of citrus fruits.

The occurrence of *Anastrepha mombinpraeoptans* in the citrus plantings in both the mountainous area and the main citrus belt appeared to be associated with the principal fruiting seasons of mango and hog plum in or near each planting. The species *A. mombinpraeoptans* very rarely, indeed, has attacked citrus fruits.

Flies apparently traveled considerable distances to reach localized sites where some of the larval infestations occurred in grapefruit in the main citrus belt. There was, nevertheless, an apparent correlation of the number of adults that occurred in the citrus plantings with the number of each species that occurred in their respective principal or preferred host trees.

The comparatively small populations of adults of both species that occurred in traps in citrus plantings were striking. At no period did the population of either *Anastrepha suspensa* or *A. mombinpraeoptans* in citrus plantings exceed the number of each species that occurred in their respective preferred host trees. The population of adults of both species in citrus plantings was infinitesimal during most of the year and could hardly be compared on the same basis with the number of flies that were trapped in the preferred host plants.

Anastrepha suspensa has not been known to breed in mango fruits in Puerto Rico, but the population of adults of this species that occurred in mango trees exceeded the number that occurred in citrus plantings throughout most of the year, and generally *A. suspensa* adults appeared to occur in mango trees to a greater extent than in citrus plantings. Apparently *A. suspensa* had a peculiar habit of migrating over large areas into various trees, including mango and citrus.

The distribution of flies of both species in the citrus plantings was apparently affected considerably by the presence of mango and other trees in the immediate vicinity. Such nearby plants, however, could not be considered the source of all flies that were trapped in the groves, and it seems probable that flies migrated to such situations to seek shelter and protection.

In the relatively small number of fruits attacked, the average infestation of immature stages per fruit has been low in citrus fruit in Puerto Rico.

Anastrepha mombinpraeoptans has not been a citrus-breeding fruitfly under normal conditions in Puerto Rico. Out of a total of 1,528 fruitflies, reared from infested citrus fruits during the period 1932 to 1938, 5 specimens only have been identified as *A. mombinpraeoptans*. The occurrence of adults of both *A. mombinpraeoptans* and *A. suspensa* in close association in the citrus planting, however, indicated a general parallelism in their migratory habits. Apparently *A. mombinpraeoptans* was even less capable than *A. suspensa* of increasing its population of adults by development in citrus fruits.

The larval infestations of the West Indian fruitfly that occurred in citrus fruits seemed to have been associated with a small but definite influx of *Anastrepha suspensa* during the latter part of February in the mountainous area, and with a similar small movement of flies into the groves in the main citrus belt about the first part of March. These sporadic attacks on the fruit were of short duration and they disap-

peared soon after the adult population had decreased; this occurred at the time when citrus fruits presumably were in prime condition for infestation.

The quantity or number of citrus fruits with larval infestation has been entirely negligible from the commercial viewpoint, and on the basis of the present information the West Indian fruitfly in the island, which is presumably its native home, may be considered not to be a menace to the citrus industry in Puerto Rico.

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